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CHELSEA CENTER FOR RECYCLING AND ECONOMIC DEVELOPMENT
UNIVERSITY OF MASSACHUSETTS

TECHNICAL REPORT #6

POTENTIAL MARKETS FOR CRTS AND PLASTICS FROM ELECTRONICS DEMANUFACTURING:

AN INITIAL SCOPING REPORT

AUGUST 1998

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POTENTIAL MARKETS FOR CRTS AND PLASTICS FROM ELECTRONICS DEMANUFACTURING:

AN INITIAL SCOPING REPORT

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CHELSEA CENTER FOR RECYCLING AND ECONOMIC DEVELOPMENT
TECHNICAL RESEARCH PROGRAM

AUGUST 1998

The Chelsea Center for Recycling and Economic Development, a part of the University of Massachusetts' Center for Environmentally Appropriate Materials, was created by the Commonwealth of Massachusetts in 1995 to create jobs, support recycling efforts, and help the economy and the environment by increasing the use of recyclables by manufacturers. The mission of the Chelsea Center is to develop an infrastructure for a sustainable materials economy in Massachusetts, where businesses will thrive that rely on locally discarded goods as their feedstock. Further information can be obtained by writing the Chelsea Center for Recycling and Economic Development, 180 Second Street, Chelsea, MA 02150.

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Introduction

This report provides an overview of potential applications and markets for two problem materials arising from the electronics demanufacturing process: cathode ray tubes (CRTs) and plastic housings. The majority of resources were devoted to CRT market development issues, since this component of the electronics waste stream is hazardous and the target of proposed Massachusetts regulation. The CRT market overview summarizes several current recycling options as well as future market opportunities, including closed and open-loop recycling, repair and refurbishment, and smelting.

For plastics, research was specifically limited to the identification of potential end markets for the plastics waste stream currently generated by the University of Massachusetts Amherst demanufacturing operation. This scoping decision was made for practical purposes: specifically, the limited timeframe for this study, as well as Chelsea Center's commitment to fund additional market development research for engineering thermoplastics in FY99.

Potential end markets for CRTs and plastics were identified through interviews with industry experts, networking, searches of available literature, databases and directories, and the Internet. Telephone interviews were then conducted with intermediate processors and potential end markets to discuss applications, processing capabilities and costs, and material specifications. A list of organizations contacted and interviewed for this study appears in Appendix A. Appendix B contains the two interview guides, one for CRT markets and the other for for plastics markets.

This initial scoping report is just the "tip of the iceberg" on market development for CRTs and plastics. The report leaves many questions unanswered and several market leads unexplored. Additional research and analysis will be needed to fill in gaps and to develop a more comprehensive assessment of markets. For example, this report identifies available options for CRTs, but does not assess their feasibility in terms of supply and demand, or compare the environmental benefits and costs of the options.

Cathode Ray Tubes: Applications and Markets

Computer monitors and televisions contain cathode ray tubes (CRT). Markets currently exist for both used equipment (i.e., whole monitors and televisions) as well as the CRT glass. Markets for used equipment depend on their working condition and the demand for used equipment or parts, while glass chemistry may dictate the potential application for CRT glass. This initial research identified markets for all forms of CRTs from whole monitors and TVs to clean, sorted cullet. For whole CRTs some equipment is more desireable than others. Some markets accept some types of cullet, and not others.

The lead content of CRT glass is the most important factor determining its potential and appropriateness for use in any given application. The lead content and chemistry of CRT glass varies by component as well as by manufacturer. Table 1 summarizes the average lead content in the components of television and monitor displays.

Table 1: CRT Composition

Component	Composition of Televisions and CRT Displays [1]	Percent of Total 27" TV Tube (by wt.)[2]
Panel glass	0-2.5% lead oxide alkali/alkaline earth aluminosilicate	66.1
Funnel glass	22 % lead oxide alkali silicate	26.0
Neck	30% lead oxide alkali/alkaline earth silicate	0.5
Stem	29% lead oxide alkali aluminosilicate	7.4
Frit	70% lead oxide zinc borate	

Table 2 provides a summary of potential applications for CRT glass. Applications are grouped into use categories to delineate the function of CRT glass, including:

- reuse;
- closed-loop glass-to-glass recycling;
- open loop glass-to-glass recycling;
- lead reutilization;
- glass aggregate; and
- export.

For example, the category "lead reutilization" refers to applications where the primary function of CRT glass is for its lead content. "Glass aggregate" refers to applications where the primary function of CRT glass is to replace other aggregates or silica. The fate of CRT recycling falling into the "export" category will vary from reuse to open loop glass-to-glass recycling to "ultimate use unknown".

[1] As referenced in "Lifecycle Analysis of CRTs", NJIT Multi-Lifecycle Engineering Research Center, http://www.njit.edu/merc/reearch/report/lca_CRT.html

[2] "Characteristics of Recycled Material," Thomson Consumer Electronics, no date.

The most promising applications for CRTs are discussed in greater detail in the following sections. Currently available markets are summarized first, followed by potential future applications of CRT glass. CRT intermediate processors (e.g., Envirocycle, Dlubak) are listed as a market for CRTs as they serve a vital role in processing monitors, televisions and bare CRTs for use in multiple end markets.

The following current markets for CRTs and CRT glass are discussed:

- refurbishment and resale;
- CRT intermediate processors;
- CRT glass manufacturing;
- industrial lead panels;
- decorative glass manufacturing;
- export; and
- smelters.

For each application, the summary lists the function of CRT glass in the process; materials generally accepted by the market; the cost or revenue;, the market capacity, if available; and companies in the market. In some cases the list of companies is fairly complete (e.g., CRT glass manufacturers), while in other cases a very limited sample of companies is listed (e.g., refurbishment, decorative glass).

Some applications of CRT glass currently in practice may not be desirable to the State. For example, the Noranda copper smelter (Toronto, Canada) accepts CRTs for processing. The CRT glass is utilized as a fluxing agent, while the lead is an unwanted by-product left behind in the slag, which is disposed of in tailing ponds. Noranda does plan to add lead recovery technology to its copper smelter, although it is not expected to be on line until 2000. Lead smelters such as those operated by Noranda (New Brunswick, Canada) and Doe Run (Missouri) can recover lead from CRT glass. The lead smelters prefer CRT glass that is crushed or in chards, and relatively clean of plastic contaminants.

This research identified some promising applications for CRT glass currently under development in the private sector and academia. The most promising future applications discovered in the course of this research were:

- x-ray shielding products; and
- decorative tile products.

Due to time contraints, some applications (e.g., lighting products[3], borosilicate cells for nuclear waste encapsulation, construction aggregates, highway reflective products,

[3] Several lighting products are reported to use small quantities of leaded glass. For example, the base of an incandescent light bulbs apparently uses about 1 gram of glass with lead. High intensity discharge lamps may also use some leaded glass.

sandblasting medium[4], and fiberglass) were not explored in depth, but are listed here for informational purposes and potential future research.

In addition to those markets discussed below, several markets were identified, but eliminated from further consideration based on the opinions of experts as to the feasibility of using CRT glass in the applications. The following applications were dropped for consideration:

- leaded glass crystal --CRT glass chemistries were considered undesirable;
- glazes in ceramics -- most glazes in ceramic tableware are now no lead;, and,
- brass and bronze manufacturing -- while lead is added to brass and bronze to increase machineability, the silica in CRT glass would not be soluble in the molten metal, resulting in solids in soft metal. This, in turn, would decrease machineability. The development of a metal or ceramic composite might be possible.

[4] This application has been developed by Proactive Environmental. Information on this use is available on their website http://www.perdi.com

Table 2: Overview of CRT Glass Applications -- Existing and Potential

Use Category	Application	Equipment or Glass type	Market Status	Potential Market Capacity[5]	Current In-State Capacity
Reuse	Refurbish & resale	Variable	Available for some equipment	Unknown	Unknown
Closed Loop Glass-to-Glass Recycling	CRT glass manufacturing	Panel & funnel glass; lead & no-lead glass chemistries	Available	Significant	None
Open Loop Glass-to-Glass Manufacturing	Decorative tile	Co-mingled CRT glass	Demonstration phase	Moderate	None
	Decorative glass products	No lead panel glass	Available	Low	Unknown
	Lighting products	No information	No information	No information	Unknown
Lead Reutilization	X ray shielding products	Co-mingled CRT glass	R&D phase	Unknown	Unknown
	Industrial glass panels	Co-mingled CRT glass	Available	Small	Unknown
	Borosilicate cells for nuclear waste encapsulation	Leaded glass or co-mingled glass	No information	No information	No information
	Lead smelting	Co-mingled CRT glass	Available	Moderate	None
Glass aggregate	Smelters: lead and copper	Co-mingled CRT glass or whole monitors (copper smelter only)	Available	Moderate	None
	Sand blasting medium	Co-mingled CRT glass	Available	Unknown	None
	Fiberglass	No information	No information	No information	No information
	Highway reflective products	No information	Unknown	Unknown	Unknown
Export	Refurbish and resale; glass bottles for pesticides	Variable	Available	Unknown	Unknown

[5] The market capacity refers to the potential capacity of this end market to absorb CRTs diverted from the Massachusetts waste stream. The end market may be in Massachusetts or out-of-state.

Current Markets for CRT Glass

Refurbishment and Resale

End product:
Equipment or parts reuse.

Process description:
- Resale as is;
- Test, remove dust/dirt, refurbish and repair, as needed, retest; or,
- Breakdown for parts reuse.

Markets for Used Equipment:
Variable, depends on equipment type, make, model, and quantity. In general, among the companies interviewed they seem to agree that there are:
- Better markets for quantities of equipment of same make and model.
- Better markets for computer monitors than TVs.
- Few resaleable monitors from residential stream.

Opinions on available markets for different products (make, model, year) vary, and given time constraints these markets were not explored in depth. Further research is clearly needed, but some observations by the companies interviewed provide some initial insights:
- Small market for monochrome tubes, if quantity is sufficient to remanufacture and resell.
- Markets for SVGA monitors, working or not working. May be able to sell VGA monitors in working condition. No market for non-working VGA monitors and monochrome monitors.
- Approximately 50 percent of all monitors are no good. Higher percentage of monochrome tubes (80-85%) are bad because they burn out faster.
- Generally market for Apple, Wang, Digital monitors -- any model, any year; working or not working.
- It is no longer worth it to buy monitors and put money into refurbishing them because no one wants to buy them.
- Approximately 10% of TVs collected in municipal program purchased ($5-10) by repair market; must be cable ready, push button models.
- Recent call from Venezuela for specific make and model TVs with transformers.

Materials Accepted:
Variable, depends on market niche of company. For example, one company only refurbishes monitors for large companies, while another buys skids of mixed equipment.

Processing Costs/Revenues:
Variable.

Companies Providing Service:
- Computrend, Inc. (Londonderry, NH): purchase, refurbish and resell monitors, printers and terminals to service companies for use in maintenance contracts.[6]
- Monitor Technology (Chelmsford, MA): repair and refurbish for large companies only.
- Non-profits also play a vital role in the reuse market.

Further research is needed to identify the firms that provide this service in the region

CRT Intermediate Processors

End Product:
CRT glass cullet for multiple purposes, including manufacture of new CRTs for US television industry, industrial glass panels, decorative glass products and tile, and smelting. Processing might limit end markets (e.g., lead/no lead composition).

Process description:
Varies from manual to mechanical processing. Process steps usually include: crush glass, remove metals, clean phosphors. Plastic housings and non-glass components (e.g., electron gun, yoke, mask) may be removed prior to crushing. Depending on end use application and market, may include separation of glass chemistries (e.g.. no lead/lead glass) visually and mechanically.

Market capacity:
Significant, but depends on capacity of end markets to utilize glass.

Materials Accepted:
- Post-industrial and post-consumer glass.
- Whole monitors, bare CRTs, broken glass.
- Currently all TVs and monitors are accepted. For CRT glass applications, this may change due to changing glass chemistries over the years, particularly for TVs. The mass recovery of old televisions could potentially alter the glass batch chemistry.

Processing Costs/Revenues:
Varies by company, ranges from about $3-10/monitor.

Companies Providing Service:
Envirocycle (Pennsylvania): preparation for CRT glass manufacturing.

[6] For sample inventory, see http://www.computrendnh.com

Dlubak Glass Co. (Ohio): preparation for CRT glass manufacturing.
DMC (Newfields, NH): preparation for lead smelter and potentially tile.

Demanufacturers in Massachusetts could utilize existing intermediate processors to access end markets such as CRT glass manufacturing. It may also be cost-effective to install CRT processing capacity in the state in order to access end markets directly. This could be accomplished in several ways: get an existing processor to expand into the state; license technology; or purchase technology. Based on discussions with Envirocycle, they may be interested in expansion into Massachusetts, or licensing their technology.

A New Jersey company, Newtech Recycling, plans to sell its patented-technology (pending) for approximately $150,000 per unit. The unit can process approximately 3,000 monitors in 8 hours in batches of 6-12 TVs or monitors at a time. CRTs are processed in a closed system (with a vacuum filter to collect leaded dust particles) using hydraulic crushing and metal separation. The end product is a glass cullet, comprised of both panel and funnel glass. Currently Newtech sends the cullet to a CRT manufacturer for use in funnel glass. The company claims that the process produces zero waste.

CRT Glass Manufacturing

End Product:
New cathode ray tubes for the US television industry.

Function of CRT Glass:
Directly replaces silica and lead oxide, the primary raw materials in CRT glass manufacturing.

Process description:
100% of glass is recycled in manufacturing process.

Market capacity:
150,000-300,000 tons annually; in 1997, approximately 25,000 tons of CRT glass (post industrial and post consumer), or less approximately 10-15 percent of the estimated capacity, was recycled in the industry.[7]

Materials Accepted:
- Post industrial and post consumer CRT glass cullet.
- Color lead and no lead glass chemistries, including panel and funnel glass. At least one manufacturer, Techneglas, only accepts no-lead panel glass since they no longer manufacturer leaded panel glass.

[7] Personal communication with Jeff Lowry, Techneglas, June 24, 1998.

- No monochome CRTs accepted by at least one glass manufacturer.
- Some glass sorting required: for example, funnel and panel glass; lead and no-lead panel glass.
- Clean of coatings and phospors.
- Approximately 100 tons/month minimum to start to sell glass directly to glass manufacturer.

As the volume of recycled CRT glass increases, it is possible that additional sorting (e.g., by manufacturer, glass transmission) may be required for this market. The glass manufacturing process can currently accomodate the subtle differences in glass chemistries, given the small quantitities of glass recycled. As recycled glass increases as a percentage of the total glass melt, additional sorting may be required to maintain the consistency of the glass batch.

Processing Costs/Revenues:
The industry pays about 50-67 percent of the virgin raw material value for recycled CRT glass cullet delivered to the plant. With the current raw material value at $300/ton, the price paid for cullet is approximately $150-200/ton.

Companies Providing Service:
Three largest US CRT glass manufacturers:
- Corning Asahi Video
- Techneglass
- Thompson Consumer Electronics

Sony Electronics recently brought 2 new furnaces on line in the US. While these furnaces currently do not accept recycled glass cullet, this market should be watched for the future.

Industrial Glass Panels

End Product:
Glass panels for industrial applications such as skyscrapers and hospitals.

Function of CRT Glass:
Lead in glass provides radiation protection.

Market capacity:
Unknown.

Materials Accepted:
Co-mingled CRT glass; all types.

Processing Costs/Revenues:
Not available.

Companies Providing Service:
Advanced Recovery, Belleville, NJ sends glass to Japanese glass manufacturer to produce these panels.

Decorative Glass Products

End Product:
Variety of decorative glass products such as vases, bowls, carafes, Christmas ornaments, paperweights, mementos, awards, trophies.

Process description:
IBM has commissioned glassware companies in the US and Sweden to design and manufacture these objects. In the US, the glass is first sorted, crushed and cleaned by Envirocycle.

Market capacity:
Small, but appears to be interest in these products for awards programs and promotional items.

Materials Accepted:
No lead panel glass from colored CRTs.

Processing Costs/Revenues:
Glassware manufacturers buy processed glass. Decorative pieces vary in price: for example, $15-20 for Christmas ornaments; $35 for decorative apples; and $60-70 for an award mounted on marble base with engraving.

Companies Providing Service:
Vitrex, Corning, New York.

Export

This report identified one promising export market, Fortune Plastics and Metal, although numerous others reportedly exist. The export market warrants further research.

End product:
Manufacture "refillable" 30 gallon glass bottles for pesticides for use by local farmers.

Process description:
CRTs are exported to China where the glass is processed at the company-owned subsidiary. The glass is granulated in an enclosed machine with water spray to prevent airborne lead dust. Process fluids are recycled and reused in the process. The glass is sent to a pesticide bottle manufacturer for manufacture into glass bottles. According to the company, the facility has been inspected and approved by several major US corporations.

Market capacity:
At least 100 tons/month of intact CRTs. Currently at about 20% of capacity.

Materials Accepted:
Whole monitors, bare CRTs; TV or computer monitors; monochrome or color.

Processing Costs/Revenues:
Low end of $3-7 range.

Companies Providing Service:
Fortune Plastic & Metal Inc., Jersey City, New Jersey

Smelters

End Product:
Saleable lead product from some smelters.

Function of CRT Glass:
CRT glass is used as a fluxing agent in the smelting process. CRT glass is a direct replacement for silica, or sand. Since smelters purchase sand, the use of CRT glass as an alternative fluxing agent lowers operating costs.

Some smelters (e.g., lead smelter) also recover lead from CRT glass as an "added bonus", while other smelters do not. Doe Run's primary lead smelter claims a >96% recovery rate for lead.[8] Currently, Noranda's Horne copper smelter does not recover lead. At the Horne smelter, lead is tied up in "slag tailings", which are permanently impounded in a non-leachable form in tailings ponds. Noranda is in the process of evaluating a new lead recovery technology for the copper smelter, which will result in a saleable lead product. This lead recovery technology is expected on line in 2000.

[8] Primary lead smelters recover lead from ore, while secondary lead smelters recover lead from alternative feedstocks such as lead-acid batteries and other lead-bearing wastes.

Market capacity:
Industry capacity is potentially large, but no actual estimates were available. Existing capacity with lead recovery is more limited. The Doe run primary lead smelter, which does recover lead, estimates its capacity for CRT glass at approximately 8,000 tons annually.

Three primary smelters that accept CRT glass were identified in the course of this research.: Doe Run's primary lead smelter; Noranda's Horne copper smelter; and Noranda's primary lead smelter. However, as discussed above, Noranda's copper smelter currently does not recover lead. Secondary lead smelters, such as Doe Run's Resource Recycling Facility that primarily recycles lead-acid batteries, apparently have a limited capacity for silica due to their alternative feedstock.

Materials Accepted:
Variable, depends on smelter. For example:

- Doe Run accepts 2-6" chards or crushed glass, although regulatory restrictions can limit the latter. Prefer not to accept whole monitors, since plastic can clog up equipment and negatively impact environmental controls.
- Noranda's Horne copper smelter accepts intact or shredded monitors.
- Noranda's lead smelter only accepts a clean glass stream, since the process is not designed to handle complex products.

Processing Costs/Revenues:
There are processing charges associated with smelting. For example, Noranda's Horne smelter charges approximately $.10/lb for intact monitors and $.07 for shredded monitors, not including transportation costs.

Companies Providing Service:
Doe Run Company: primary lead smelter (Missouri)
Noranda Metallurgy: copper smelter (Quebec, Canada); lead smelter (New Brunswick, Canada)

Promising Future Markets

Xray Shielding Products

The New Jersey Institute of Technology (NJIT) Multi-Lifecycle Engineering Group is working on the application of co-mingled CRT glass in xray shielding products. NJIT has demonstrated the technical feasibility of this product concept, and is now conducting product and market testing. A market study and cost assessment is expected by year end.

CRT glass would require minimal preparation for this end use. No sorting or separation of glass chemistries would be required. CRTs would be crushed, and metals and phospors removed.

A variety of end products are envisioned, including

- fabric wall coverings;
- building blocks (6" X 6" X 4") for wall construction, which could be used to create portable xray facilities; and
- tile squares (4-6") with decorative ceramic coatings.

Decorative Ceramic Tile

Futuristic Tile LLC developed a patented technology for the production of masonry-like building products using recycled glass. The tiles can be produced in a range of colors and textures, including the appearance of natural stones such as granite or marble and ceramic tiles.

The production process utilizes 100 percent recycled glass cullet, including approximately 85 percent 3 color mix or other silica-based waste in the "bottom layer" and 15 percent clear glass cullet in the "top layer" of the process. In conjunction with DMC, an electronics recycler based in New England, Futuristic Tile is experimenting with the use of CRT glass in its production process. Initial results indicate that CRT glass is acceptable as a raw material in the bottom layer, while its use in the top layer needs additional testing.

The economics of using CRT glass in this application depend on 2 factors: 1) whether the glass is used in the bottom or top layers of the process; and 2) transportation costs. Futuristic Tile currently takes materials for the bottom layer at no charge, while they pay for clear cullet. The generator pays transportation costs.

Futuristic Tile currently operates a research and pilot production plant in Wisconsin. Future expansion is planned for multiple locations in the midwest and in New York State. The company is interested in pursuing additional production facilities as well, including Massachusetts, if there is interest in the State. A "typical" production facility would utilize approximately 22,000 tons of glass cullet to manufacture 5 million square feet of product, and could employ 35-40 people operating in 3 shifts.

Plastics

During the UMass Amherst demanufacturing process, plastic housings are removed from the CPUs and printers, in order to access and recover valuable materials and components inside. The plastic housings currently go to a local landfill for disposal. The goal of this study was to identify potential recycling markets for the plastic computer housings from the UMass Amherst demanufacturing facility.

While no data is available, it is reasonable to assume that the UMass plastics stream is composed of the variety of resin types found in electronic equipment manufacturered over the past 15 years or so, including ABS, ABS/PC, PVC, Noryl, and high impact PS. In this initial study, markets are explored for this mixed resin stream, since resin identification and sorting can be a difficult and costly process.

In searching for markets, there were two main objectives:

- to identify companies that currently accept mixed resin housings from electronics equipment for recycling; and,
- to assess the potential for companies that process plastics (i.e., feedstock to manufacturers) or manufacture plastics products with recycled content to accept mixed engineering thermoplastics materials.

Fifteen companies, including recycled plastics processors, compounders, and end markets, were interviewed for this study. Potential markets were identified through prior knowledge of the industry, the demanufacturing survey, several published directories.[9], and the American Plastics Council Recycled Plastics Products Database. A good cross section of companies and the best leads were contacted for this study, resulting in the identification of several markets and the emergence of several market trends, as discussed below. Time constraints limited the number of companies that could be contacted. Additional research (i.e., extensive telephone calling) may reveal some additional markets. Markets for mixed plastic resins are limited, but several market options exist or have potential, including:

- granulate mixed resins for use in asphalt paving products (available market);
- export to China for sorting, granulation, and sale to product manufacturers (available market); and,
- manufacture low-end, large-piece or thick-walled products such as pallets or lumber with mixed resins (potential market).

Table 3 provides a summary of these markets and companies in the Northeast that accept/process mixed plastic housings from electronic products, or may be willing to accept these materials.[10] Several companies are plastics processors who sell to end

[9] For example, the Chelsea Center. *Massachusetts Directory of Recycled Products Manufacturers* (April 1997); Mass WasteCap, *Recycling Services Directory*(May, 1998); and Buy Recycled Business Alliance, *Massachusetts Directory of Recycled Product Suppliers.*

[10] Similar companies in these markets might also accept these materials.

markets, while others manufacture end products. The materials accepted by these markets range from loose or baled mixed plastic housings to granulated resins relatively free of metal contaminants.

There are processing costs (in the vicinity of $.03-.10/lb) associated with the two currently available markets for mixed plastic housings identified in this study: asphalt paving products and export. Processing costs could decrease, perhaps to no cost, if local manufacturing applications for mixed resins could be further developed and marketed. Two plastics processors suggested a closed-loop system, where the generator of the plastics purchase the end product, guaranteeing a market.

Co-mingled plastics are more difficult to find markets for than single resin materials, and have a lower market value. One final option, therefore, is to identify and sort the plastics, either manually or using plastic separation and cleaning technologies. The biggest issue is not whether it is technically feasible to sort, but whether it can be done economically.

Some demanufacturing companies visually identify and sort plastic parts, then grind the sorted plastics and process to remove metal contaminants. Three companies that manually sort plastics were interviewed for this study. One company sorts ABS only and uses this resin to manufacture printer cable connectors. The second company, an exporter who sends the plastics to its subsidiary in China, manufactures small component housings for the electrical industry (e.g., electric outlet boxes for inside walls). The third company sells its granulated resins to brokers. Brokers were cited by several companies interviewed, including one broker, as paying anywhere from $.05 - .22/lb depending on the type of resin and quality.

Several companies in the US, including one company in Massachusetts, Recycling Separation Technologies (RST), have perfected processes for separating mixed plastic granulate into single resin products. These companies can take whole plastics housings, grind and granulate the plastics, mechanically separate resin types (e.g., density separation) and remove metal, rubber, and paper contaminants to produce a clean feedstock. These single resins can be introduced into a greater variety of applications than mixed resins, even replacing virgin materials in high performance electronics applications.

Six of the fifteen firms contacted for this study that process ABS and other engineering resins, including 2 of the 3 exporters, accept single resin materials of known composition with little or no contamination with metal, paper, or adhesives (i.e., currently mostly post-industrial scrap). These companies may accept whole items (e.g., spools, styrene tubes) or granulate. On-site processes may include limited testing of resin type, grinding, custom compounding, and manufacture of end product. Most of these companies are not interested in getting into the business of sorting mixed engineering resins, or have tried it already with limited success.[11]

[11] For example, ReVamp Inc., Marsh Plastics, The Plastics Group of America, Kaiser Plastics, Oriental Export, Plastic Resale Corp.

Table 3: Available Markets for Mixed Plastics from Electronics

	Material Accepted	Process Description	End Product	Processing Cost/Revenue	Comments
American Reclamation Corporation (AMREC) Charlton, MA	Granulated plastic 3/8" minus sieve size, no significant metal or other contamination	Blend with other aggregates and asphalt in "cold mix asphalt emulsion process; plastic replaces gravel of similar size in process; max. 10-20% plastic due to gradation specifications for raw materials	Asphalt products, including paving and landfill cover	Current tip fee $25-30/ton	Market capacity for plastics is limited by beneficial use permits, and available markets for "cold mix" asphalt products. Currently there is no Mass Highway approval for cold-mix asphalt, which limits the available market for this product.
Atlon Laboratories Natick, MA	Co-mingled resins; granulate <1"; some metal contamination acceptable	Modified compression molding	Chock blocks, pallets, plastic lumber	No cost, delivered to facility, or possibly small tipping fee	Currently not full-scale commercial operation, which may limit the volume of materials accepted
Conigliaro Industries Framingham, MA	Loose or baled plastic housings	Shred equipment, granulate plastics	Granulate (3/8") for AMREC's asphalt paving products	Processing cost $15-30/bale[12] plus asphalt plant tipping fee @ $20-35/ton	Frequently cited end market for electronic deman-ufacturers surveyed
Fortune Plastic and Metal Jersey City, NJ	Loose plastic housings (also electronic equipment & CRTs); plastics with flame retardants accepted	Export to Chinese subsidiary where plastic is visually identified, sorted, cleaned, granulated & pelletized	Granulate or pellets sold to end users to manufacture new products such as electrical switch boxes	Processing cost <.10/lb, plus shipping	Several major US corporation have visited and approved the operation, according to the company. (References available.)
Recycling Separation Technologies Lowell, MA	Loose plastic housings with metals pieces removed; contaminated shredded or granulated plastics	Grind, liberate and remove contaminants (labels, metals, adhesives) using proprietary cleaning process; sort resins with density separation; most economical to target 1-2 resins for separation	Clean, single-resin, granulate Demonstrated technical feasibility of manufacturing pallets from "waste plastics" (i.e., plastics with no market or low value)	Processing cost about $.20/lb (grind, sort, & clean)	Strictly toll processor; company would consider processing plastic housings to produce clean, single resin product and pallet manufacturing, but not interested in owning these final products; needs 1-2 million lbs annually to get into these mixed plasticst
SelecTech Taunton, MA	If feasible, clean (no metals), co-mingled granulate	Unknown	Unknown, but probably as filler for thick-walled product	Unknown, but probably get material for free or pay small fee	Willing to entertain market development project

[12] According to one demanufacturer, a bale of mixed plastics weighs 800-1,000 pounds.

Appendix 1: Organizations Contacted & Interviewed

CRT Interviews

Electronics Recyclers with CRT Processing Capabilities
Advanced Recovery, Belleville, New Jersey
DMC, Newfields, New Hampshire
EPA Inc., New Jersey (processes Union County municipal electronics)
Newtech Recycling Company Inc., Bridgewater, New Jersey

Refurbishers
Computrend Inc., Londonderry, New Hampshire (refurbisher)
Monitor Technology, Chelmsford, MA

CRT Processors
Envirocycle, Hallstead, Pennsylvania
Dlubak Glass Co., Upper Sandusky, Ohio

Exporter
Fortune Metals and Plastic, Jersey City, New Jersey

CRT End Markets
Conversion Technologies, Orlando, Florida
Doe Run Company, Herculaneum, Missouri
Futuristic Tile LLC, Allenton, Wisconsin
Noranda Metallurgy Inc., Toronto, Canada
Techneglass

Monitor & Television Manufacturers
IBM Corporation
Matsushita Electric Corporation of America (Panasonic)
NEC Technologies (Georgia)
Sony Electronics

Trade Organizations
American Ceramics Society
Electronics Industries Alliance, Arlington, Virginia
Institute for Scrap Recycling Industries (ISRI)
International Crystal Federation
Society of Glass and Ceramic Decorators

Industry Experts
Dr. Reggie Caudill, NJ Institute of Technology, Multi-Lifecycle Engineering Center
Dr. Ed Aqua, Gordon Institute, Tufts University (metallurgist)

Plastics Interviews

Plastics Processors & Compounders
A&B Recycling, Oglethorpe, Georgia
Advanced Recovery, Belleville, NJ
Conigliaro Industries Inc., Framingham, MA
Marsh Plastics, Amherst, MA
Plastics Group of America, Woonsocket, RI
Plastic Resale Corp., W. Springfield, MA
Recycling Separation Technologies, Lowell, MA
ReVamp Inc., Concord, New Hampshire

Plastic End Markets
American Reclamation Corporation (AMREC), Charlton, MA
Atlon Laboratories, Inc., Natick, MA
Envirowood, Inc., Alabama
SelecTech, Taunton, MA

Exporters
Fortune Metals and Plastic, Jersey City, New Jersey
Kaiser Overseas, New York
Oriental Exports, Braintree, MA

Plastics Industry Associations
American Plastics Council (database search)
Massachusetts Plastics Alliance

Plastics Industry Experts
Dr. Robert Malloy, Dept of Plastics Engineering, University of Massachusetts Lowell
Dr. Reggie Caudill, NJ Institute of Technology, Multi-Lifecycle Engineering Center

Appendix 2: Survey Questions

CRT Processors & End Markets

1. In what application(s) do you use recycled CRT glass (or recycled glass cullet)?

2. What sources of glass do you use (e.g., post-consumer, industrial scrap)?

3. Process description/capabilities (from incoming material stream to outgoing product). What is the function of CRT glass in the process? What raw materials/feedstock would CRT glass replace in the process? What, if any, are the benefits of using CRT glass in process?

4. [If not using CRT glass] What is the potential for using CRT glass in your process?

5. How much post-consumer CRT glass or monitors do you process annually?

6. What is your capacity (or your industry's capacity) for post-use CRT glass/monitors? Do you expect your capacity to use post-consumer CRT glass to increase or decrease in the next five years? By how much?

7. What are the specifications for incoming materials?

- Form (e.g., whole monitors, bare CRTs, broken glass, mixed glass cullet, sorted glass cullet, clean glass)?

- Specific glass types, compositions, age (e.g., leaded/non-leaded, monochrome/color, tv/computer monitors)?

- Minimum quantity/volume?

8. What is the cost/revenue?

Does this include transportation costs?

9. How many people does your company employ (or are employed to process CRT glass)? (Or as a result of using post-use CRT glass, do you employ additional people?)

10. Would you consider expansion of your operation into Massachusetts? What is the minimum volume of material needed for expansion?

11. Are you aware of other potential applications for CRT glass?

Survey Questions
Plastics Processors & End Markets

1. Do you process recycled plastics? Do/can you process post-consumer engineering thermoplastic resins from electronic products?

2. What are your sources of recycled thermoplastic resins (e.g., post-consumer, industrial regrind)? What type of electronic equipment are the recycled plastics from?

3. What products are made from the recycled resins? What percentage recycled content?

4. Process description/capabilities (from incoming material to outgoing product).

5. [If not using recycled thermoplastics] What is the potential for using recycled thermoplastic resins in your process/product?

6. How much post-consumer engineering thermoplastics do you process annually?

7. What is your current processing capacity for recycled resins? Do you expect your capacity to increase or decrease in the next five years?

8. What are the specifications for incoming materials?

- Resin types accepted
  - Mixed
  - ABS
  - ABS/PC
  - PC
  - HIPS
  - PVC
  - Noryl

  Other

  Not Accepted:

  Are flame retardants an issue?

- In what form do you accept materials (e.g., loose carcasses, bales, granulate, pellets)

- Level of sorting and cleaning required (e.g., purity, acceptable contaminants - metals, coatings, etc.)

- Minimum volume

9. What is the cost/revenue?
Does this include transportation costs?

10. How many people are currently employed by your company (to process plastics)? (Or as a result of using recycled resins, how many additional people do you employ?)

11. Would you consider expansion of your operation into Massachusetts? What is the minimum volume of material needed for expansion?

12. Are you award of other potential applications/processors of engineering thermoplastics?